

Oxygen and redox potential gradients in the rhizosphere of alfalfa grown on a loamy soil

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Abstract

© 2015 WILEY-VCH Verlag GmbH & Co. KGaA, Weinheim. Oxygen (O₂) supply and the related redox potential (EH) are important parameters for interactions between roots and microorganisms in the rhizosphere. Rhizosphere extension in terms of the spatial distribution of O₂ concentration and EH is poorly documented under aerobic soil conditions. We investigated how far O₂ consumption of roots and microorganisms in the rhizosphere is replenished by O₂ diffusion as a function of water/air-filled porosity. Oxygen concentration and EH in the rhizosphere were monitored at a mm-scale by means of electroreductive Clark-type sensors and miniaturized EH electrodes under various matric potential ranges. Respiratory activity of roots and microorganisms was calculated from O₂ profiles and diffusion coefficients. pH profiles were determined in thin soil layers sliced near the root surface. Gradients of O₂ concentration and the extent of anoxic zones depended on the respiratory activity near the root surface. Matric potential, reflecting air-filled porosity, was found to be the most important factor affecting O₂ transport in the rhizosphere. Under water-saturated conditions and near field capacity up to -200 hPa, O₂ transport was limited, causing a decline in oxygen partial pressures (pO₂) to values between 0 and 3 kPa at the root surface. Aerobic respiration increased by a factor of 100 when comparing the saturated with the driest status. At an air-filled porosity of 9% to 12%, diffusion of O₂ increased considerably. This was confirmed by EH around 300 mV under aerated conditions, while EH decreased to 100 mV on the root surface under near water-saturated conditions. Gradients of pO₂ and pH from the root surface indicated an extent of the rhizosphere effect of 10-20 mm. In contrast, EH gradients were observed from 0 to 2 mm from the root surface. We conclude that the rhizosphere extent differs for various parameters (pH, Eh, pO₂) and is strongly dependent on soil moisture. Copyright

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Keywords

Air-filled porosity, Hotspots, Oxygen diffusion, Rhizosphere, Soil aeration